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Health effects of desert dust

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Rome, 11 March 2019

inDust

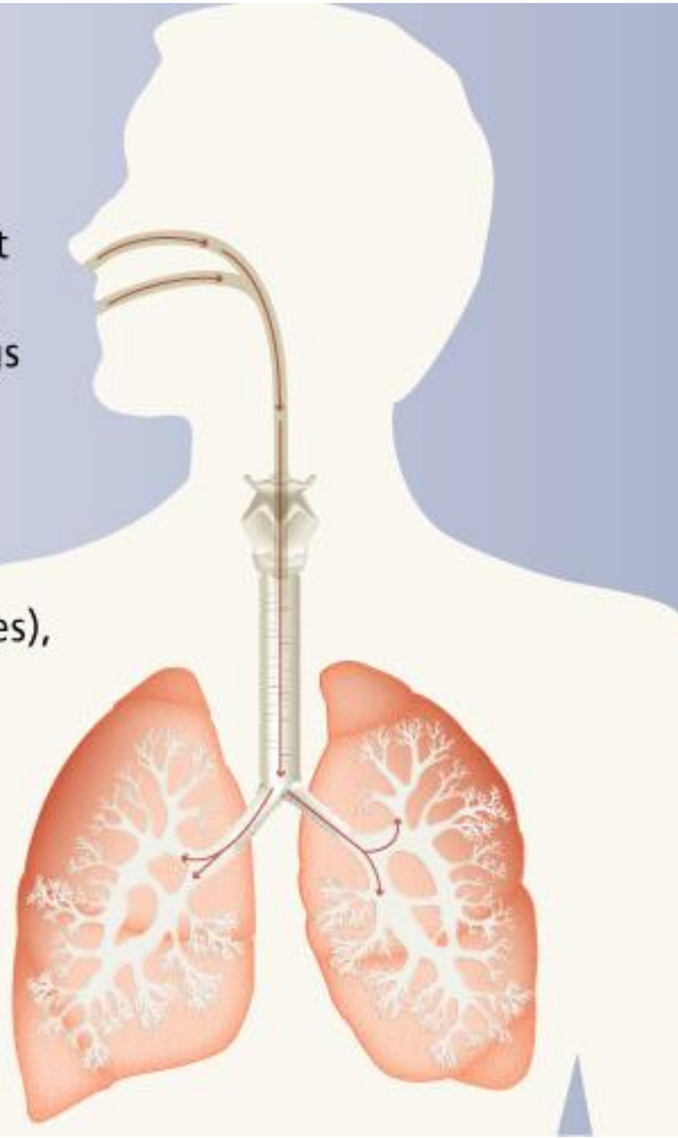
OUTLINE

- Health effects of PM. Mechanisms
- Health effects of fine versus coarse PM
- Desert dust and health. Overview and mechanisms
- Evidence from Europe and Central America
- The MED-PARTICLES project
- Evidence from Asia
- Concluding remarks

HEALTH EFFECTS OF PM. MECHANISMS

WHAT ARE THE HEALTH RISKS OF PARTICULATE MATTER?

Particulate matter poses a serious health risk because it can travel into the respiratory tract. PM2.5 is especially dangerous because it can penetrate deep into the lungs and sometimes even into the bloodstream.



HEALTH EFFECTS

- Decreased lung function
- Chronic bronchitis
- Increased respiratory symptoms
- Cardiac arrhythmias (heartbeat irregularities),
- Heart attacks
- Premature death

GROUPS SENSITIVE TO PM2.5

- People with heart or lung disease
- Older adults
- Children
- Pregnant women

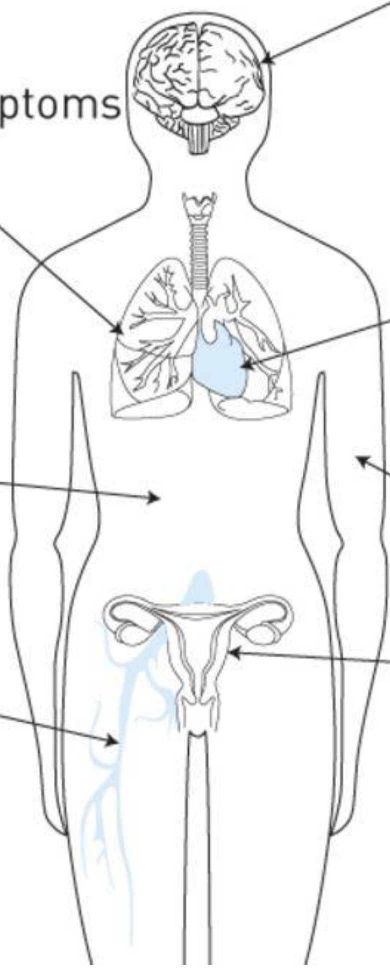
Source: www.epa.gov

HEALTH EFFECTS OF PM. MECHANISMS

Respiratory disease mortality
Respiratory disease morbidity
Lung cancer
Pneumonia
Upper and lower respiratory symptoms
Airway inflammation
Decreased lung function
Decreased lung growth

Insulin resistance
Type 2 diabetes
Type 1 diabetes
Bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood coagulation
Systemic inflammation
Deep venous thrombosis



Stroke
Neurological development
Mental health
Neurodegenerative diseases

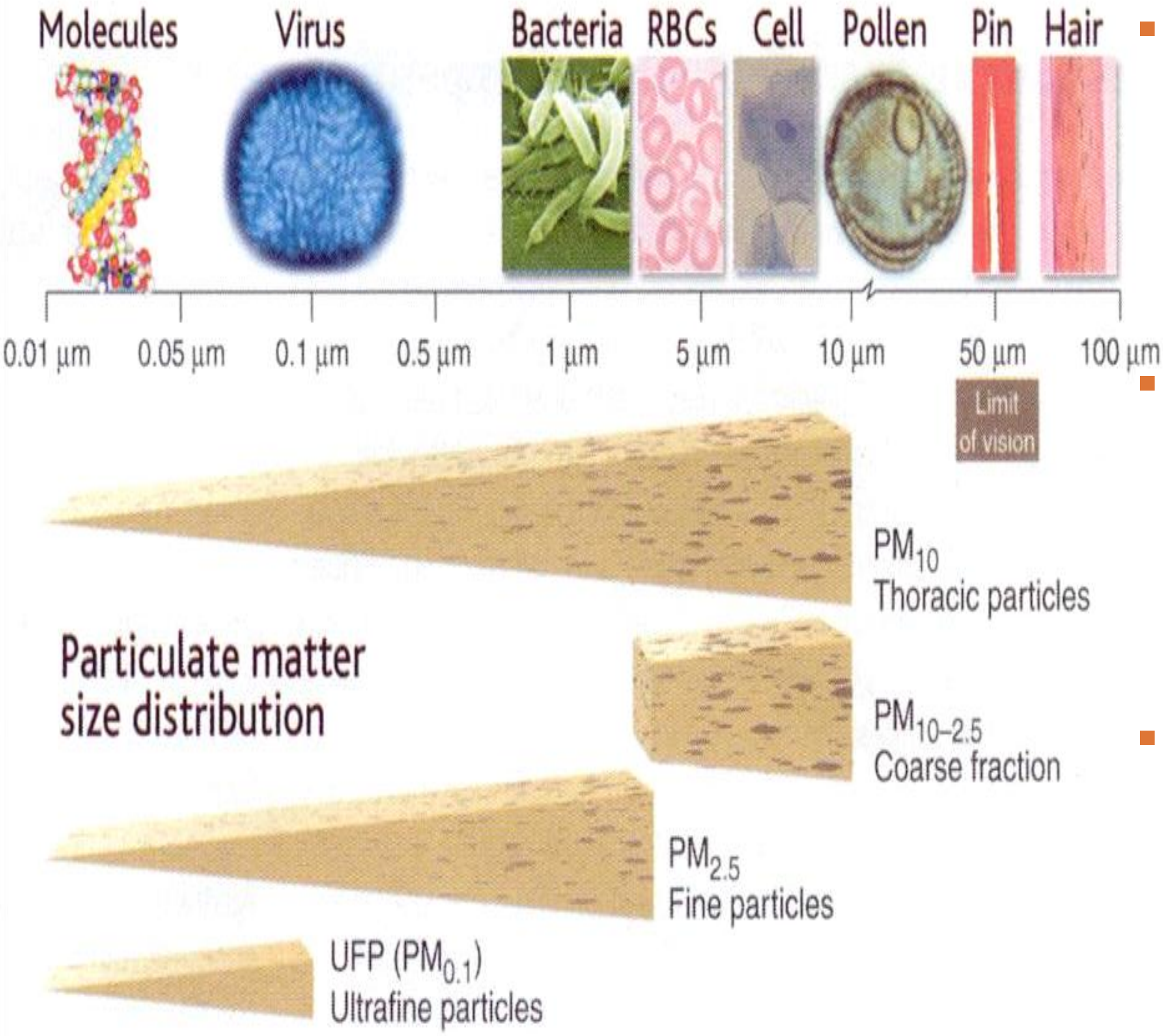
Cardiovascular disease mortality
Cardiovascular disease morbidity
Myocardial infarction
Arrhythmia
Congestive heart failure
Changes in heart rate variability
ST-segment depression

Skin ageing

Premature birth
Decreased birthweight
Decreased fetal growth
Intrauterine growth retardation
Decreased sperm quality
Pre-eclampsia

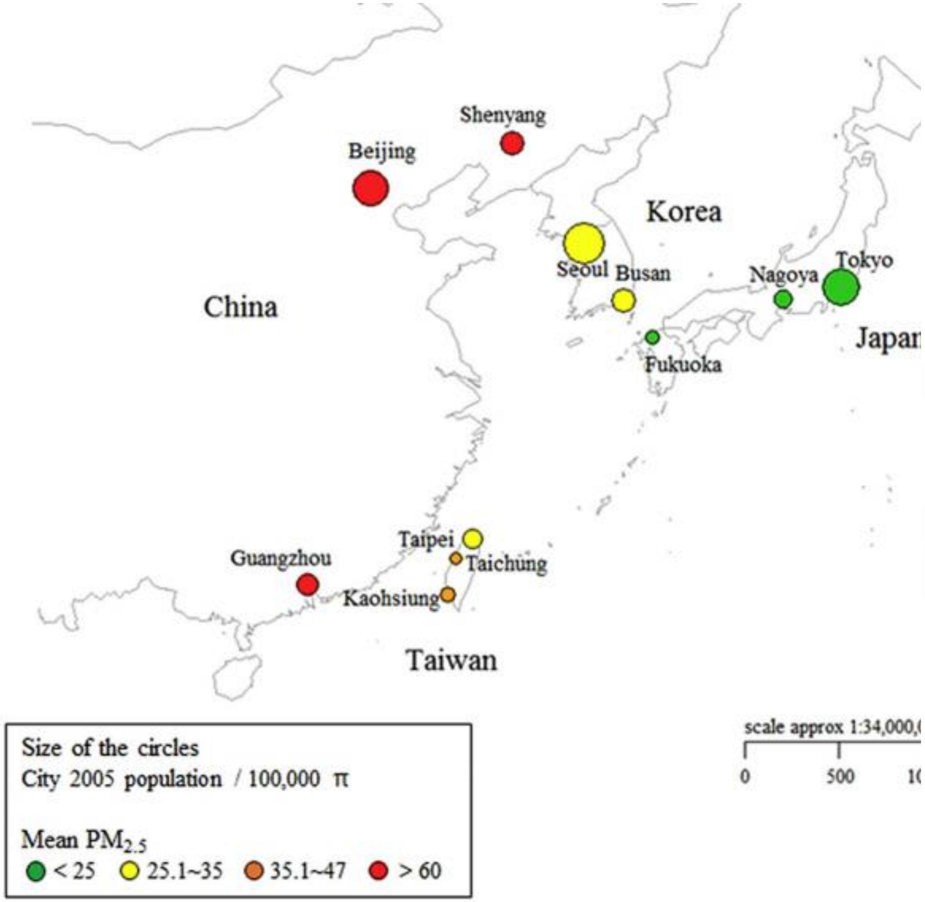
Source: ERS 2017

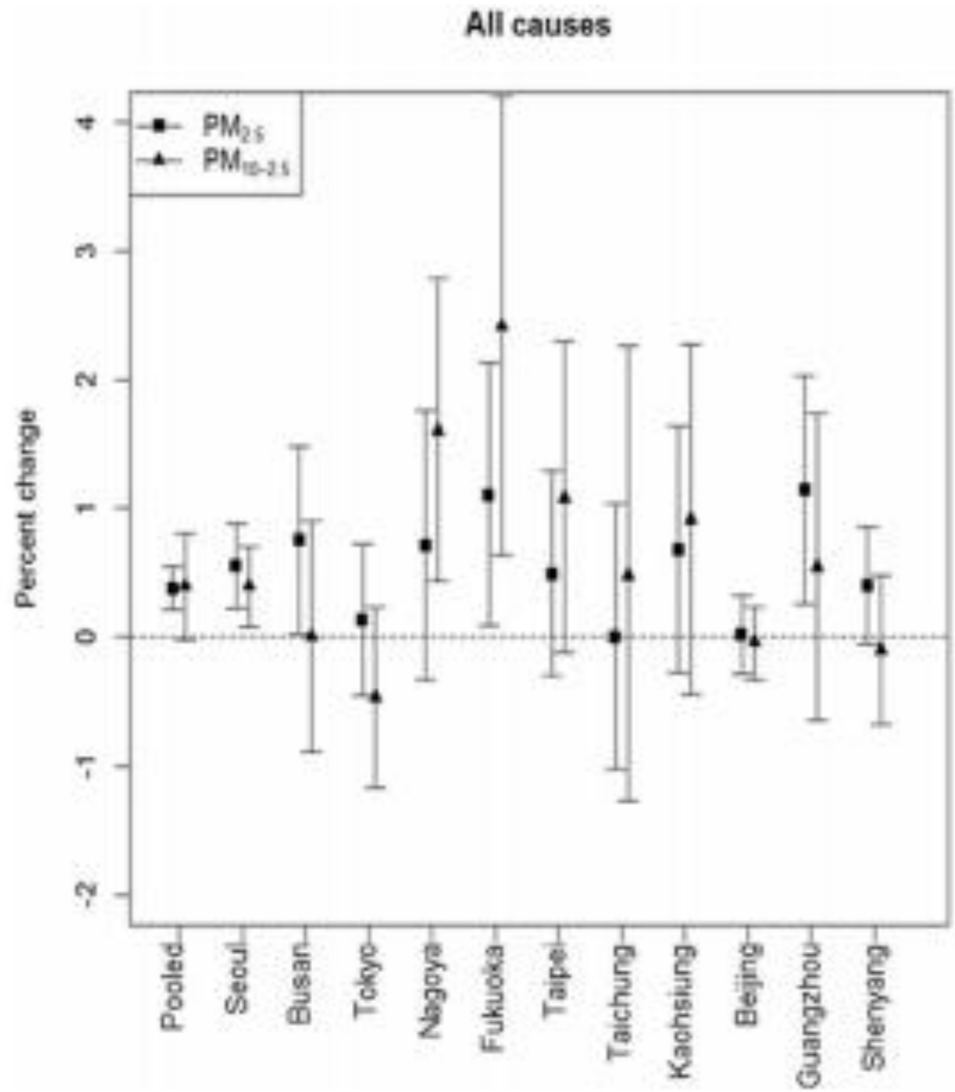
FINE VERSUS COARSE PM



- **Most evidence for $PM_{2.5}$**, as it can easily penetrate into the lungs, possibly translocating in the blood
- **Traffic** and other city-related **anthropogenic sources** presumed more toxic
- **Increasing evidence on the coarse fraction**, with excess mortality/morbidity comparable to what found for $PM_{2.5}$

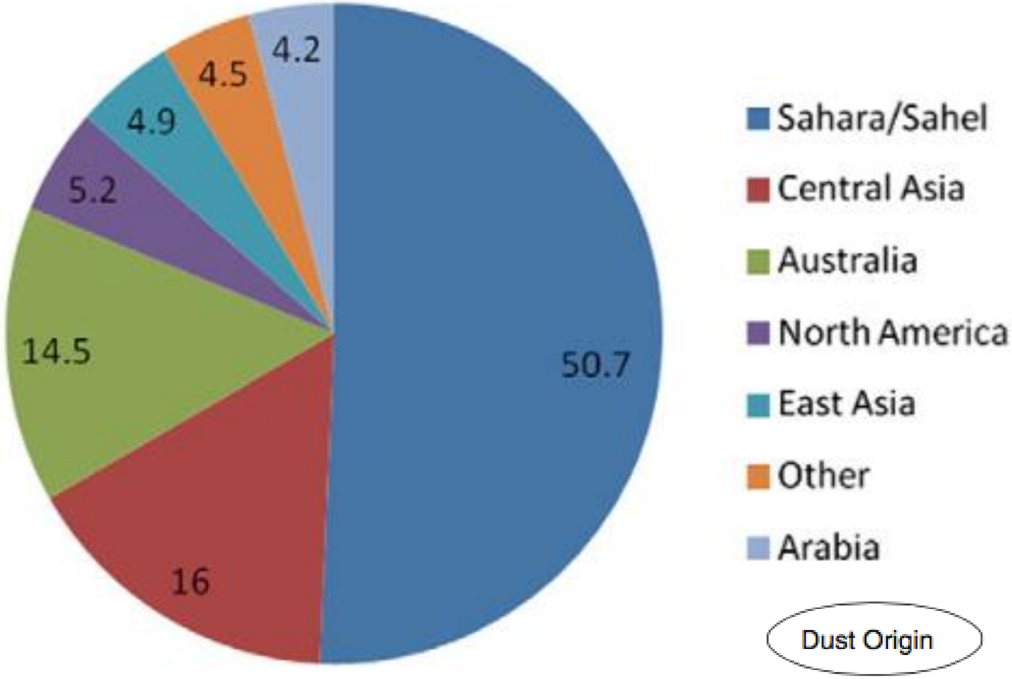
FINE VERSUS COARSE PM



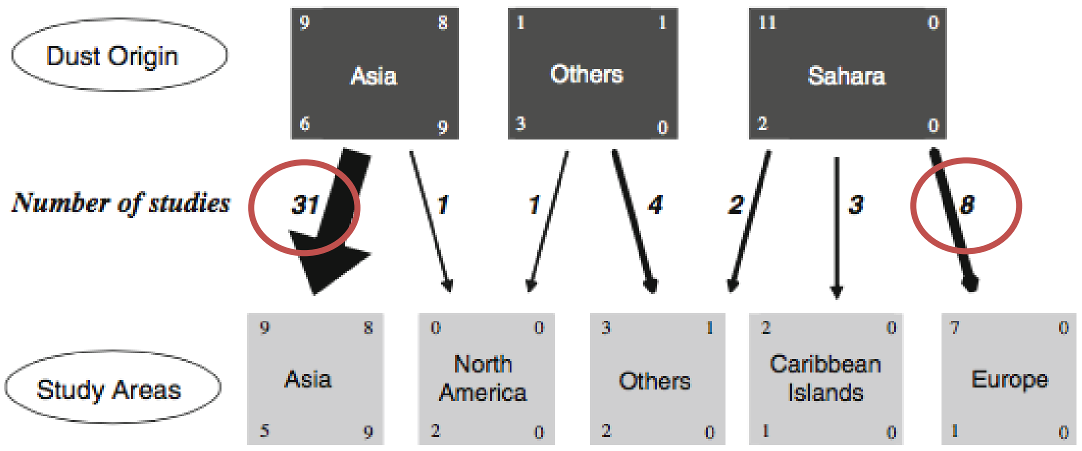


Source: Lee et al. Environ Pollut. 2015

DESERT DUST AND HEALTH. AN OVERVIEW



(Source: Goudie, Env Int 2014)



(Source: Longueville, Int J Biometeorol 2013)

DESERT DUST AND HEALTH. MECHANISMS

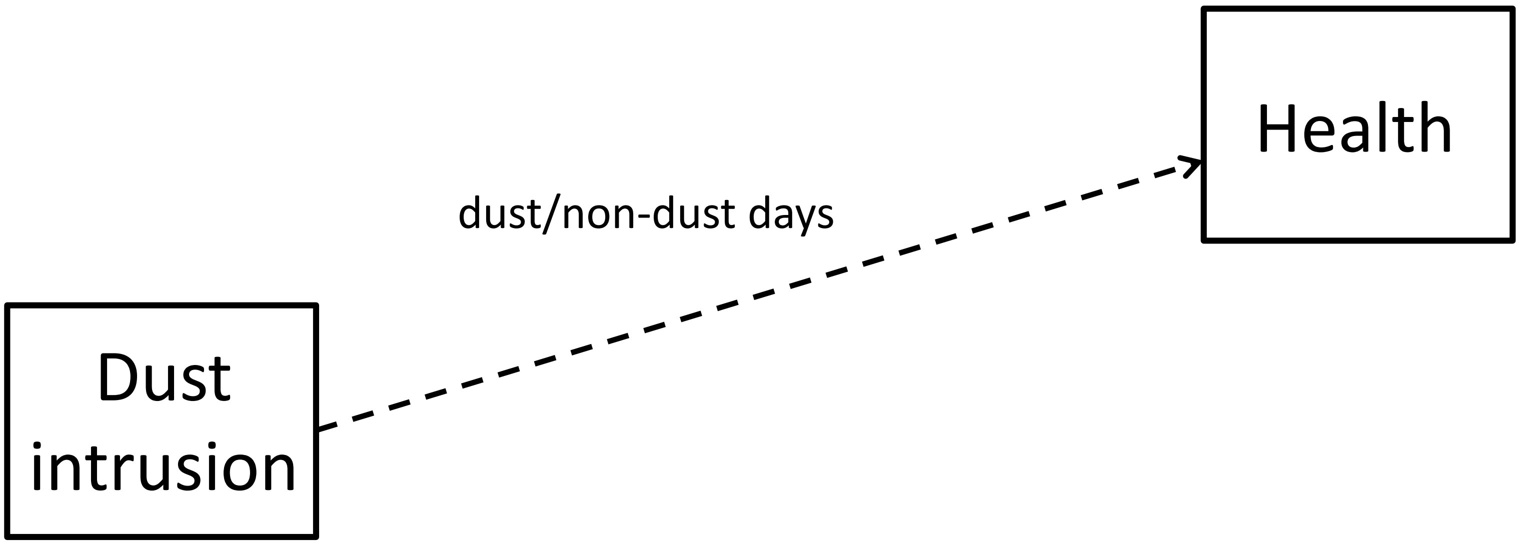
Transportation

- Dust clouds carry large amounts of microorganisms and toxic biogenic allergens *(Griffin 2007)*
- Dust cloud absorbs industrial pollutants through its journey over industrialised areas *(Rodríguez et al. 2001)*

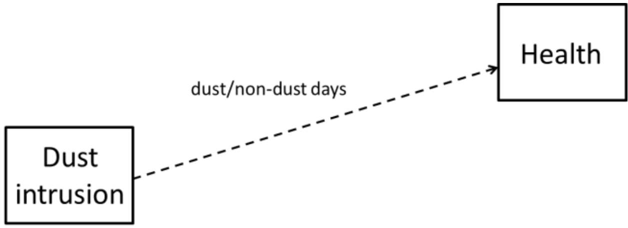
Toxicity

- Local particles more toxic on dust days due to reactions with gases or condensation of organic compounds on the particles *(Pérez et al. 2012)*
- Dust episodes associated with a lowering of the MLH enhancing local pollution *(Pandolfi et al 2014)*

1. Effects of dust intrusions (yes/no)



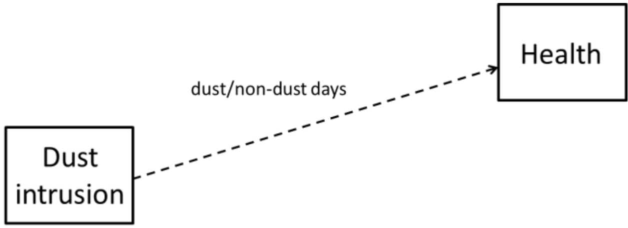
Short-term effects on mortality



City (Country)	(Yr. Pub.)	RESPIRATORY
Barcelona (SP)	(2008, 2012)	
Madrid (SP)	(2010, 2012)	
Rome (IT)	(2011)	
Emilia-Romagna (IT)	(2011)	✓
Athens (GR)	(2011)	
Nicosia (CY)	(2013)	

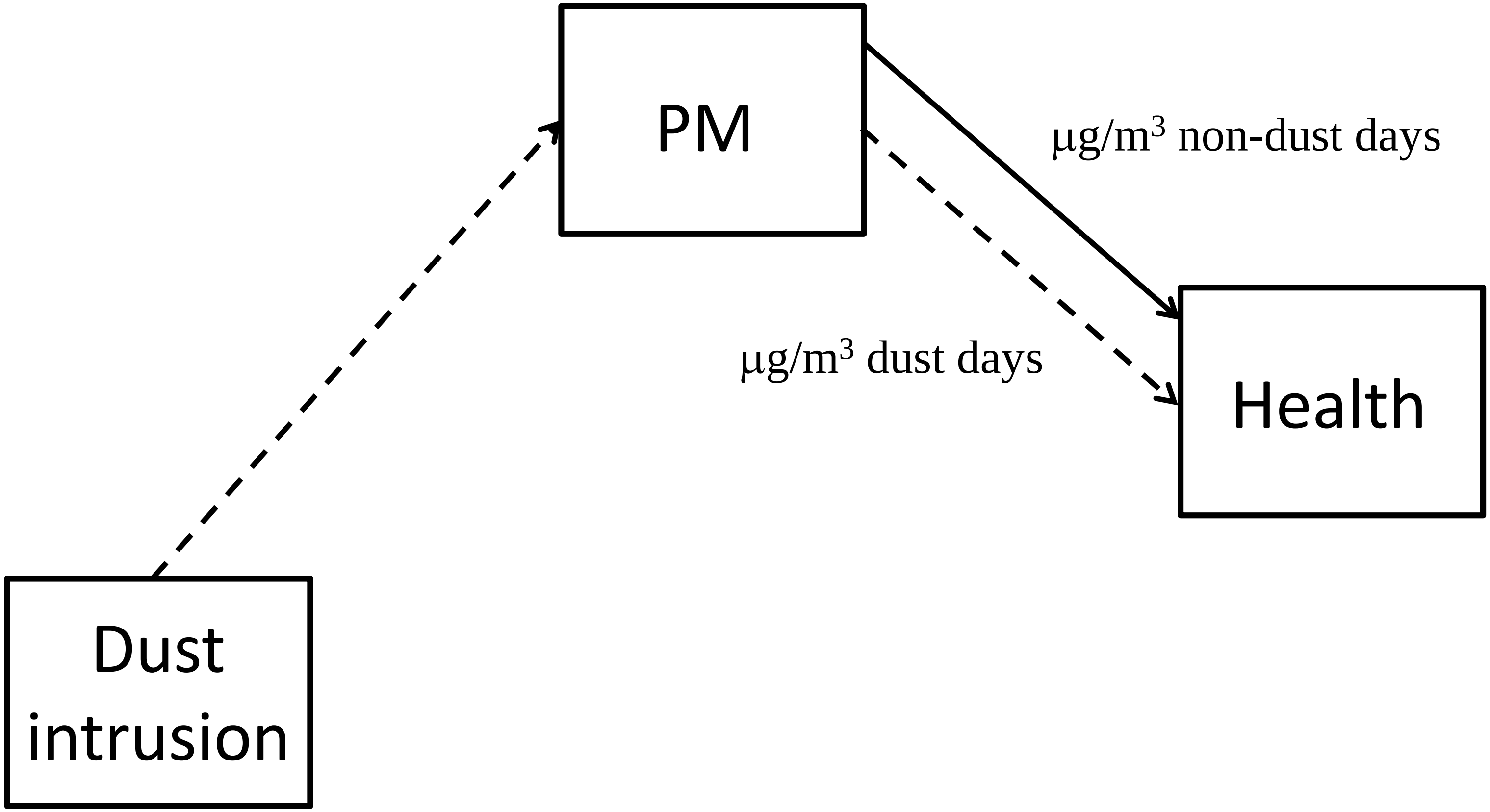
EVIDENCE FROM EUROPE AND AMERICA

Short-term effects on morbidity



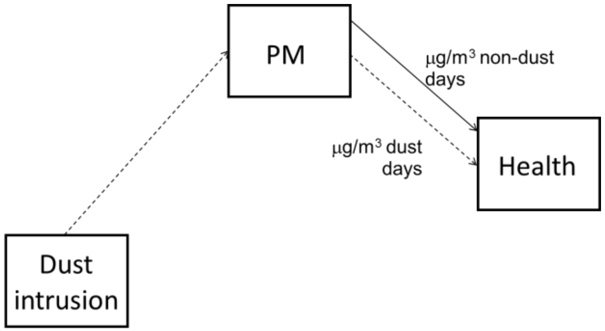
City (Country)	(Yr. Pub.)	Respiratory	Asthma (< 14 yrs)	COPD
Trinidad (Caribbean)	(2005)		✓	
Nicosia (CY)	(2008)	✓		
Trinidad (Caribbean)	(2009)		✗	
Athens (GR)	(2011)			
Rome (IT)	(2013)			
Madrid (SP)	(2014)			
Be’er Sheva (ISR)	(2014)			✓
Guadeloupe (Caribbean)	(2014)			
Grenada (Caribbean)	(2015)		✓	

2. Effects of PM modified by dust intrusions



EVIDENCE FROM EUROPE AND AMERICA

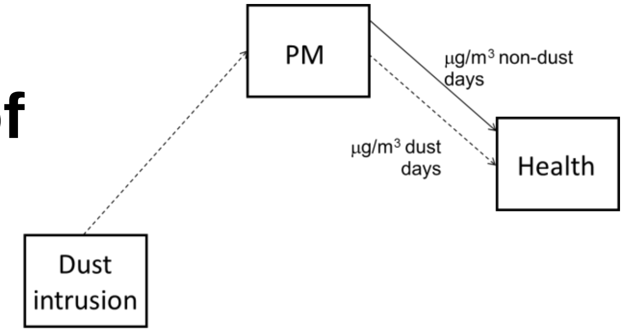
Short-term effects on mortality



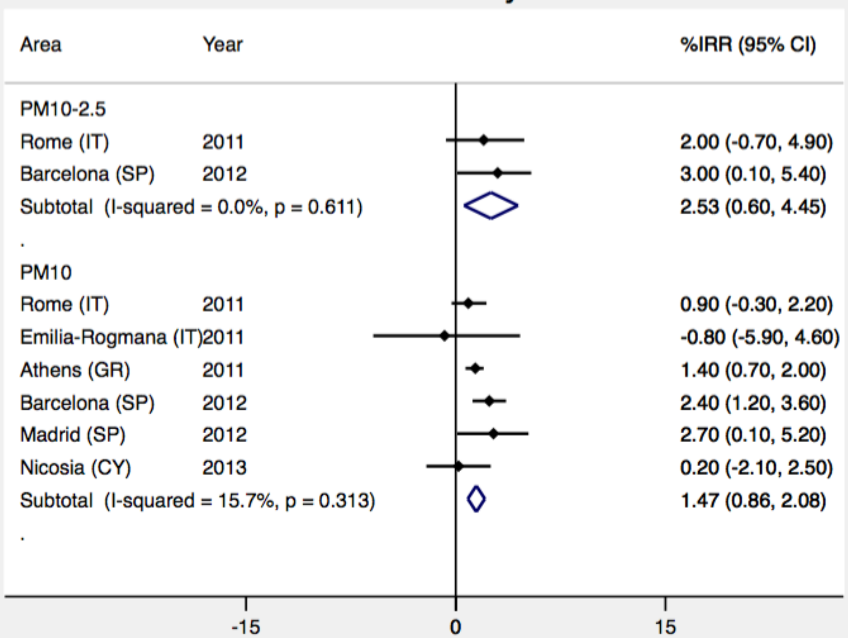
		African dust as effect modiffier of							
		$PM_{10-2.5}$	PM_{10}	$PM_{10-2.5}$	PM_{10}	$PM_{10-2.5}$	PM_{10}	$PM_{10-2.5}$	PM_{10}
City (C.)	(Yr. Pub.)	All natural		CVD/Circ.		Cerebrovascular		Respiratory	
Barcelona (SP)	(2008, 2012)	✓		✓	✓	✗		✗	
Madrid (SP)	(2010, 2012)	✓	✓		✓				✗
Rome (IT)	(2011)	✓	✓	✓	✓	✗	✗	✗	✗
Emilia-Romagna (IT)	(2011)		✗		✗				✗
Athens (GR)	(2011)		✗		✗				✗
Nicosia (CY)	(2013)		✗		✓				✗

EVIDENCE FROM EUROPE AND AMERICA

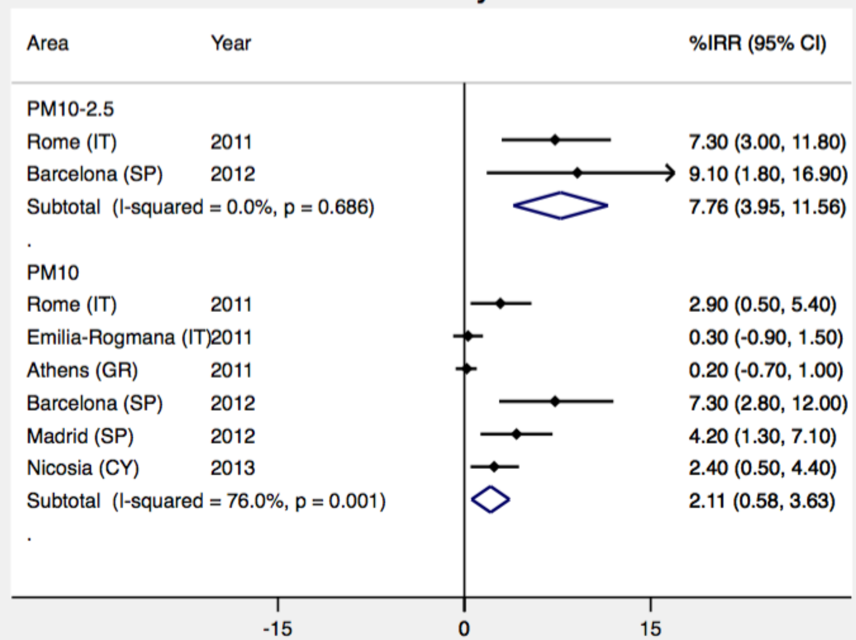
Meta-analysis of published risks of cardiovascular mortality for an increase of 10 μg/m³ of PM during Saharan and non-Saharan dust days in Southern Europe



Non-dust days

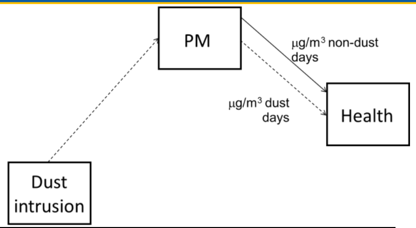


Dust days



EVIDENCE FROM EUROPE AND AMERICA

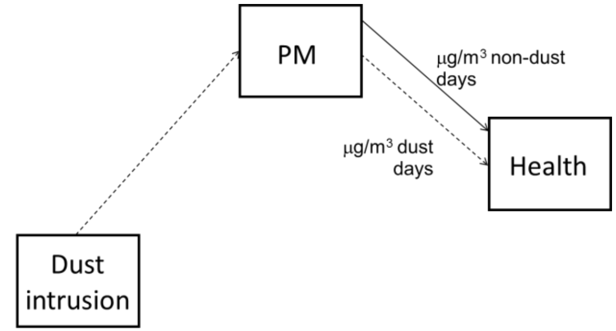
Short-term effects on morbidity

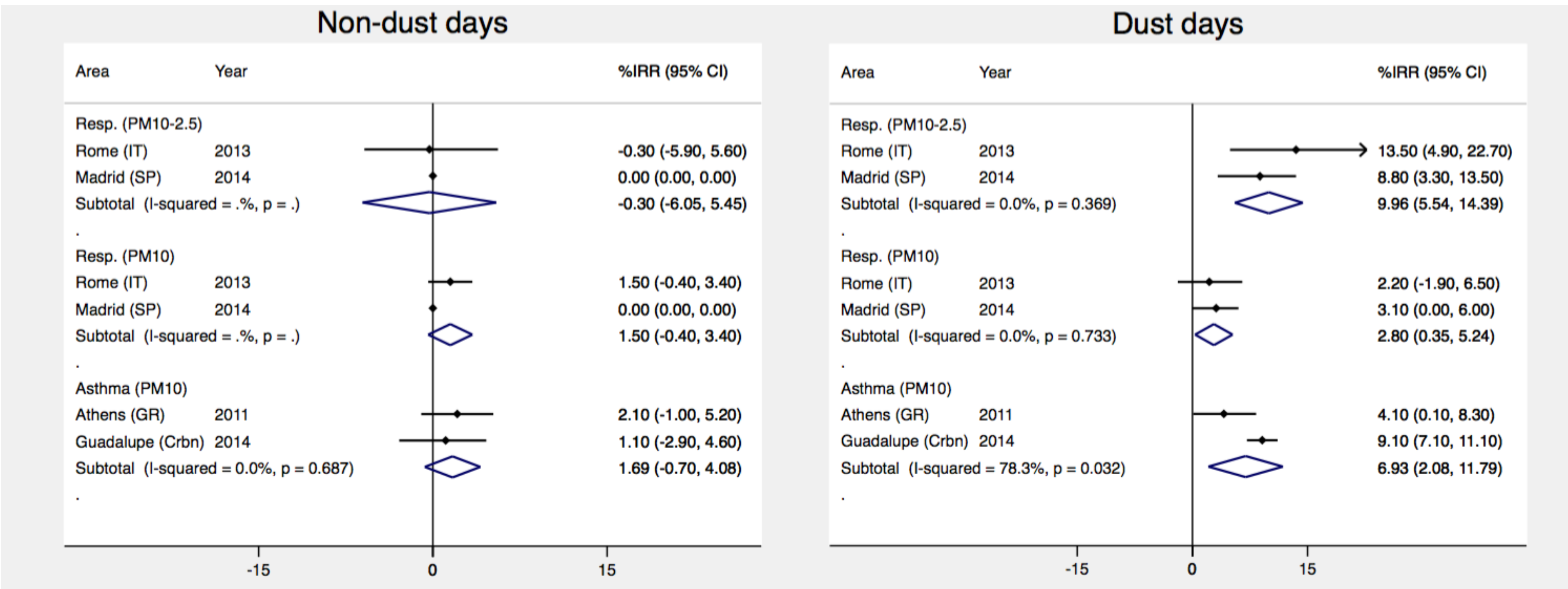


		African dust as effect modiffier of							
		$PM_{10\text{-}2.5}$	PM_{10}	$PM_{10\text{-}2.5}$	PM_{10}	$PM_{10\text{-}2.5}$	PM_{10}	$PM_{10\text{-}2.5}$	PM_{10}
City (C.)	(Yr. Pub.)	CVD/Circ.		Respiratory		Asthma (<14)		COPD	
Trinidad (Caribbean)	(2005)								
Nicosia (CY)	(2008)								
Trinidad (Caribbean)	(2009)								
Athens (GR)	(2011)						✓		
Rome (IT)	(2013)	✗	✗	✓	✗				
Madrid (SP)	(2014)	✗	✗	✓	✓				
Be'er Sheva (IS)	(2014)								✗
Guadeloupe (Caribbean)	(2014)					✓	✓		
Grenada (Caribbean)	(2015)								

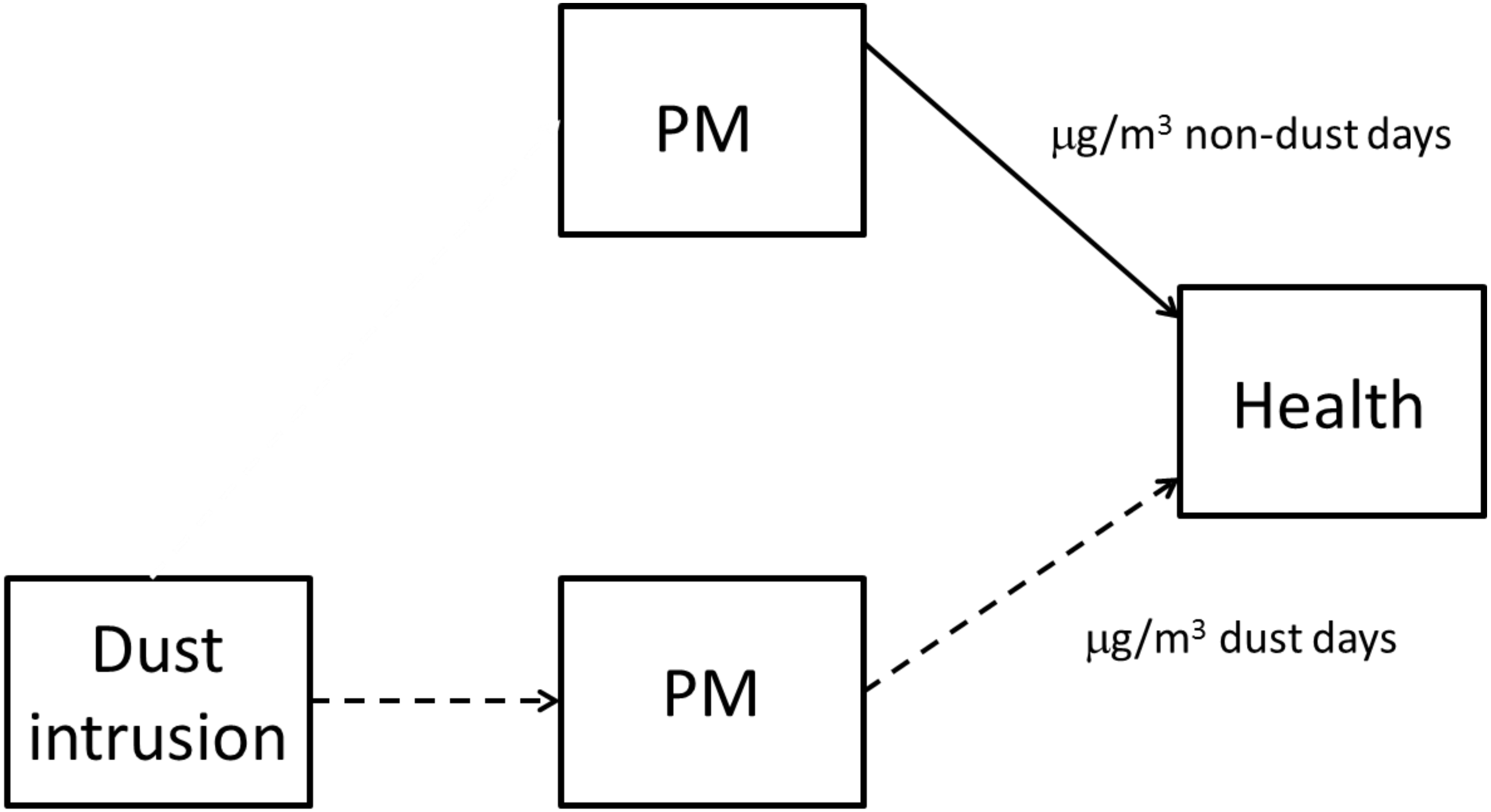
EVIDENCE FROM EUROPE AND AMERICA

Meta-analysis of published risks of hospital admissions for respiratory and child asthma causes, for an increase of 10 μg/m³ of PM during Saharan and non-Saharan dust days in Southern Europe





3. Effects of *local* PM and *natural* dust



EVIDENCE FROM EUROPE AND AMERICA

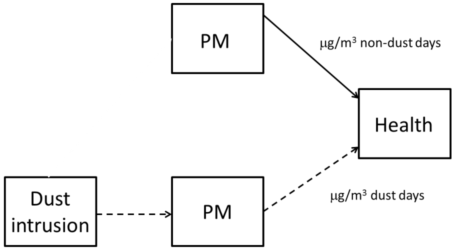


TABLE. Levels of PM_{10} and Percentage Increase in Risk of Cardiovascular Mortality 10 $\mu g/m^3$ During Non-Saharan Dust Days (Contributing Total PM_{10} Levels) and Saharan Dust Days (Contributing Local and Saharan Contributions to PM_{10} Levels)

			Percentiles				Short-term Effects	
	Mean (sd)	Minimum	25	50	75	Maximum	Lag	%IR (95% CI)
Non-Saharan dust days (n = 1317)								
PM_{10}	38.6 (15.7)	7.0	27.0	35.9	47.1	107.6	Lag 0	1.1 (−0.1 to 2.4)
							Lag 1	2.8 (1.6 to 4.1)
							Lag 2	1.7 (0.5 to 2.9)
							Lag 3	0.3 (−0.9 to 1.6)
Saharan dust days (n = 145)								
Local contributions to PM_{10}	27.7 (10.7)	0.0	20.6	27.5	34.6	53.0	Lag 0	4.9 (−0.3 to 10.3)
							Lag 1	9.7 (4.3 to 15.3)
							Lag 2	6.3 (1.1 to 11.8)
							Lag 3	7.3 (2.0 to 12.8)
Saharan contributions to PM_{10}	16.5 (12.0)	0.0	8.0	13.0	23.0	57.0	Lag 0	3.0 (−1.5 to 7.6)
							Lag 1	4.0 (−0.4 to 8.7)
							Lag 2	2.2 (−2.2 to 6.8)
							Lag 3	3.5 (−1.0 to 8.1)

(Pérez et al., Epidemiol 2012)

MED-PARTICLES: THE DATA

MEDPARTICLES

Air pollutants concentrations:
PM10, PM2.5-10, PM2.5

Mortality data: mortality by cause (natural, CVD, respiratory

(Hospitalizations by cause)

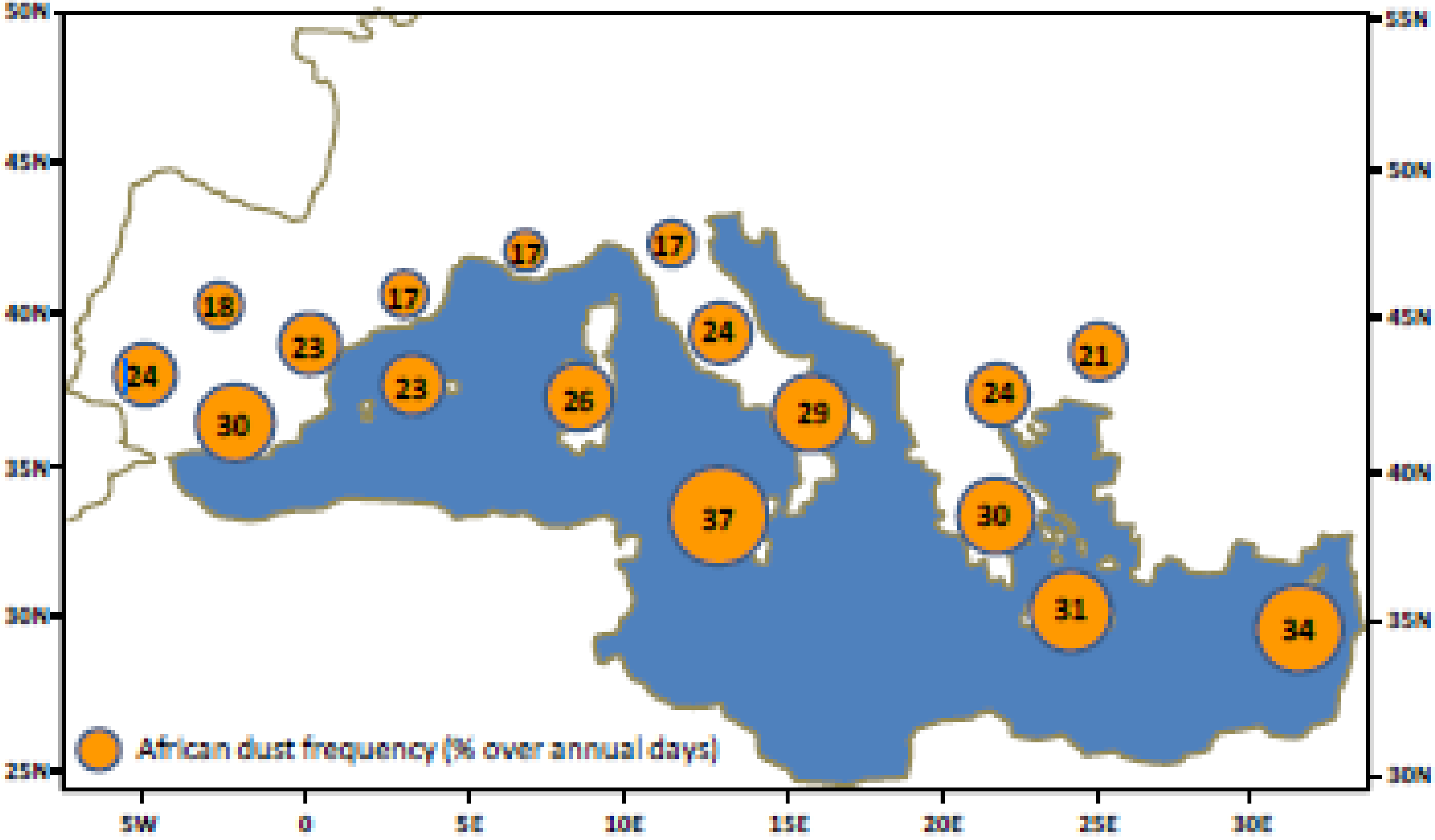
Saharan dust data:
events (0/1), Saharan PM, "local" PM

10 CITIES
Athens, Thessaloniki, Rome, Milan, Turin, Bologna, Emilia Romagna, Barcelona, Madrid, (Palermo), Marseille

Meteorological parameters:
temperature, humidity, barometric pressure, wind speed/direction

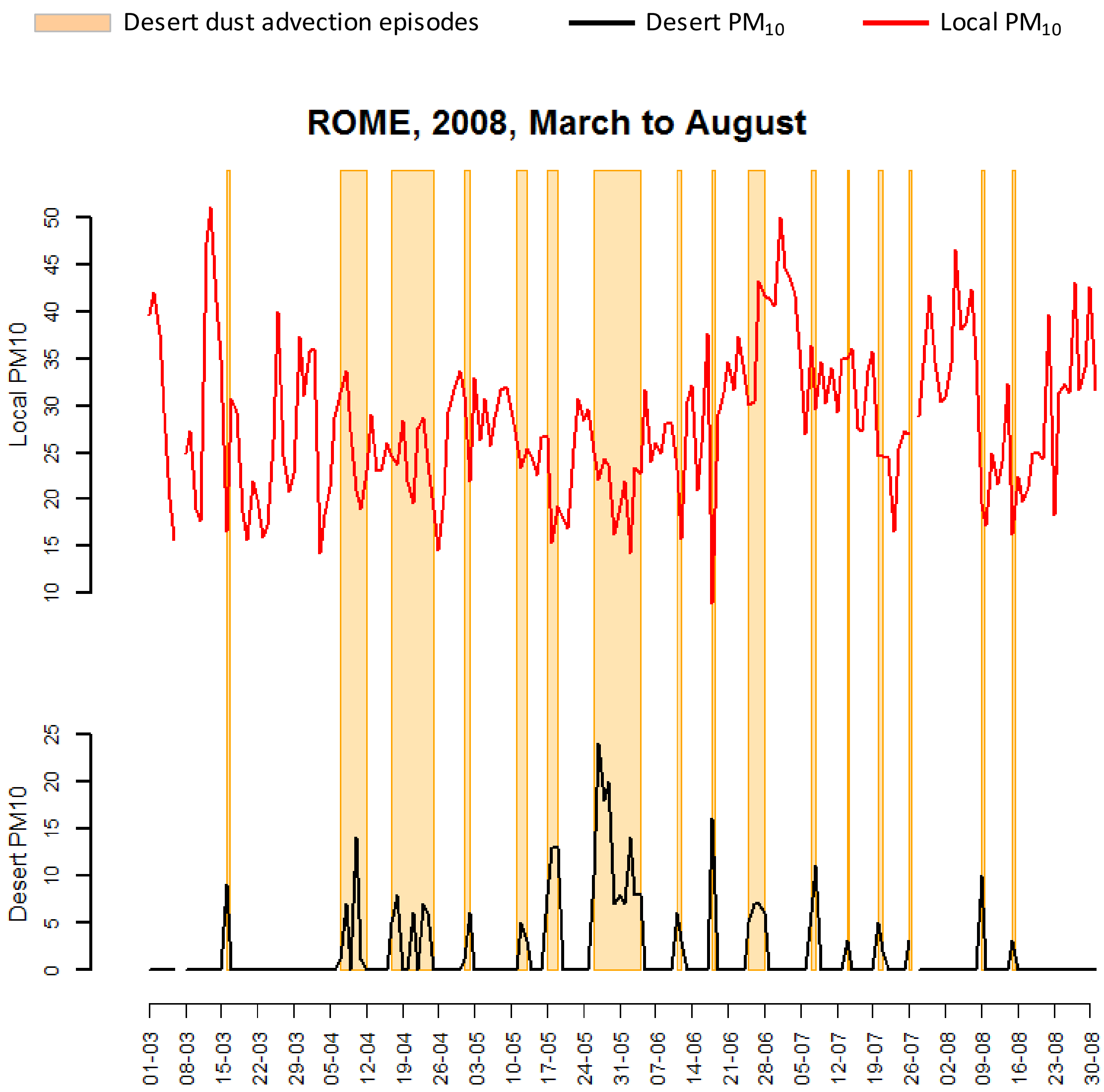
Study periods between 2003 and 2010 (3 – 7 years)

MED-PARTICLES: THE RESULTS



Source: Pey et al. ACP 2013

MED-PARTICLES: THE RESULTS



MED-PARTICLES: THE RESULTS

Table 3. Estimated percent increase (95% CI) in risk of mortality and hospital admissions associated with 10-μg/m³ increase in non-desert and desert PM_{10}.[a]

Outcome	Lag days	PM_{10} % IR (95% CI)	PM_{10} I^2	PM_{10} Het p-value	Non-desert PM_{10} % IR (95% CI)	Non-desert PM_{10} I^2	Non-desert PM_{10} Het p-value	Desert PM_{10} % IR (95% CI)	Desert PM_{10} I^2	Desert PM_{10} Het p-value
Mortality										
Natural	0–1	0.51 (0.27, 0.75)	22	0.23	0.55 (0.24, 0.87)	32	0.15	0.65 (0.24, 1.06)	0	0.75
Cardiovascular	0–5	0.66 (–0.02, 1.34)	40	0.08	0.49 (–0.31, 1.29)	46	0.04	1.10 (0.16, 2.06)	0	0.77
Respiratory	0–5	2.01 (0.92, 3.12)	31	0.15	2.46 (0.96, 3.98)	41	0.07	1.28 (–0.42, 3.01)	0	1.00
Hospital admissions										
Cardiovascular, age ≥ 15	0–1	0.29 (0.00, 0.58)	41	0.10	0.37 (–0.04, 0.78)	59	0.02	0.32 (–0.24, 0.89)	0	0.50
Respiratory, age ≥ 15	0–5	0.69 (0.20, 1.19)	32	0.17	0.62 (0.03, 1.21)	21	0.27	0.70 (–0.45, 1.87)	10	0.35
Respiratory, age 0–14	0–5	1.66 (0.93, 2.39)	0	0.47	1.82 (0.77, 2.88)	24	0.23	2.47 (0.22, 4.77)	9	0.36

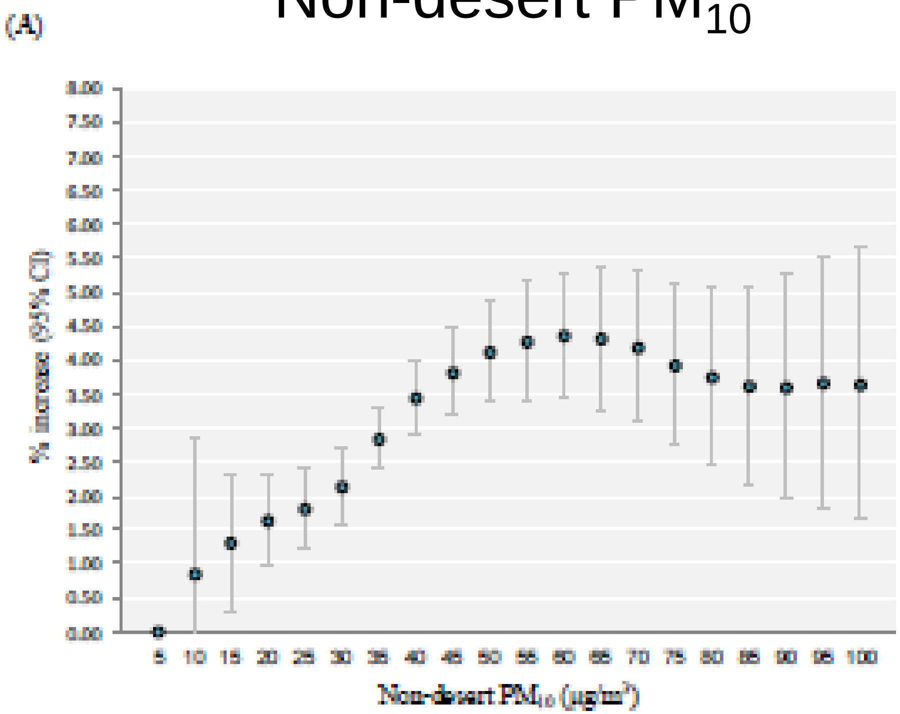
I^2 statistics represents the amount (%) of heterogeneity among city-specific estimates; Heterogeneity (Het) p-value is calculated from the χ^2 test on the Cochran's Q statistic.
[a]The estimates for non-desert and desert PM_{10} are obtained from two-pollutant models adjusted for the other PM source in turn, whereas the estimates for PM_{10} are from single-pollutant models.

Source: Stafoggia et al. EHP 2015

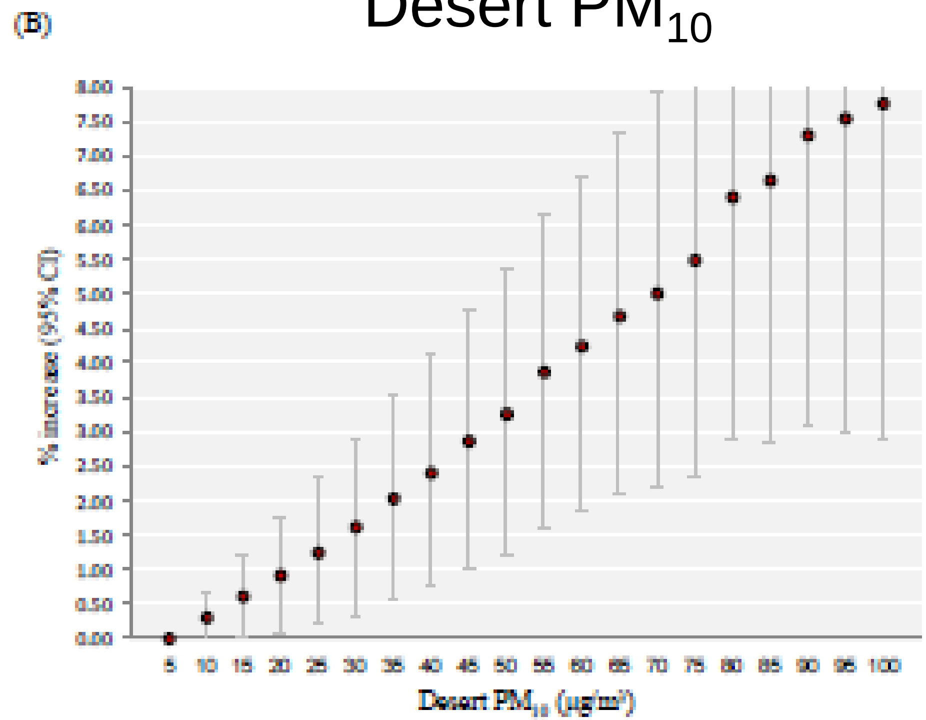
- Similar effect of all PM metrics during dust and no-dust days
- Important effect of Saharan PM on natural and CVD mortality, lower on respiratory mortality, with no evidence of heterogeneity across cities
- Similar conclusions for hospital admissions

MED-PARTICLES: THE RESULTS

Non-desert PM_{10}



Desert PM_{10}



Source: Stafoggia et al. EHP 2015

EVIDENCE FROM ASIA

Short-term effects on respiratory morbidity

Country	City	Health outcome	Dust exposure	Results
Japan		Respiratory symptoms	DUST yes/no	✓
Japan		Allergic symptoms in pregnant women	DUST yes/no	✓
Japan	Yonago	Respiratory symptoms	Dust loads (ug/m3)	✓
Taiwan	Taipei	Pneumonia admissions	DUST yes/no	✓
China	Lanzhou	Respiratory admissions	DUST yes/no	✗
Hong Kong	Hong Kong	Respiratory admissions	PM and DUST yes/no	✗
Mongolia		Eye and respiratory symptoms	Living close/far from desert	✗
Japan	Toyama	Asthma exacerbations in children	DUST yes/no	✓
South Korea	Seoul	Pulmonary function in children	PM and metals from dust	✗
South Korea	Seoul	Atopic asthma	DUST yes/no	✓
Taiwan	Taipei	Pneumonia admissions	DUST yes/no	✓
Taiwan	Taipei	Respiratory admissions	DUST yes/no	✓
South Korea	7 cities	Asthma admissions	DUST yes/no	✓
China	Minqin	Respiratory admissions	DUST yes/no	✓

Short-term effects on cardiovascular morbidity

Country	City	Health outcome	Dust exposure	Results
Japan	Fukuoka	Incidence of AMI	DUST yes/no	✓
Taiwan	Taipei	Stroke admissions	DUST yes/no	✓
Taiwan	Taipei	Congestive hearth failure adm.	DUST yes/no	✓
Taiwan	Taipei	Cardiovascular admissions	DUST yes/no	✓
Taiwan	Taipei	Stroke admissions	DUST yes/no	✓
China	Minqin	Cardiovascular admissions	DUST yes/no	✗
South Korea	7 cities	Stroke admissions	DUST yes/no	✓
Taiwan	Taipei	Cardiovascular admissions	DUST yes/no	✗

EVIDENCE FROM ASIA

Short-term effects on cause-specific mortality

Country	City	Health outcome	Dust exposure	Results
Japan	47 cities	Cause-specific mortality	DUST yes/no, PM	✔
South Korea	Seoul	All-cause mortality	PM on dust VS no dust days	✘
Taiwan	Taipei	Cause-specific mortality	DUST yes/no, PM	✘

CONCLUDING REMARKS

Reviews conclusions (1)

- **Hashizume et al. 2010** – *"… many combinations of outcomes and lagged exposures examined, some suggested possible associations of dust exposure with an increase in mortality and hospital admissions due to cardiovascular and respiratory diseases …"*

- **Karanasiou et al. 2012** – *"… association of $PM_{2.5}$ with total or cause-specific mortality is not significant during Saharan dust intrusions. Regarding PM_{10} and $PM_{2.5-10}$ an answer cannot be given. Some of the studies state that they increase mortality during dust days while others find no association …"*

CONCLUDING REMARKS

Reviews conclusions (2)

- **Longeville et al. 2013** – *“A number of adverse health effects, including respiratory, cardiovascular and cardiopulmonary diseases, are associated with dust.”*

- **Zhang et al. 2014** – *“.. respiratory and circulatory mortality, both positive and negative associations have been reported for* PM_{10} *of desert dust, but only a positive relationship was reported between* $PM_{2.5\text{-}10}$ *and mortality, and a positive relationship was also reported between* $PM_{2.5}$ *and human mortality.”*

Methodological challenges

- Different role of desert dust, based on a binary metric not properly suitable for a continuous exposure
- Different health outcomes, age groups, PM exposures and lag structures *(Hashizume et al. 2010)*
- Different methods to identify desert dust intrusions *(Karanasiou et al. 2012)*
- Different types of study designs and statistical analyses *(Longueville et al. 2013)*

Conclusions

- The body of evidence from affected areas suggest potential health effects of desert dust
- More studies are needed using a standardized protocol for desert dust detection and quantification, health data collection and epidemiological investigation in different geographical locations
- Better understanding of the potential mechanisms of toxicity

Thank you

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